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Matsumoto et al.

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[54] **CIRCUIT BREAKER DEVICE**

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[73] Assignee: **Yazaki Corporation**, Tokyo, Japan

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[7] **H01H 3/00**; H01H 15/00

[52] **U.S. Cl.** ..... **200/293**; 200/17 R; 200/16 E

[58] **Field of Search** ..... 200/1 R, 1 V, 200/5 R, 16 B, 16 E, 17 R, 18, 51 R, 51.01, 51.05–51.09, 51.12, 51.13, 243, 284

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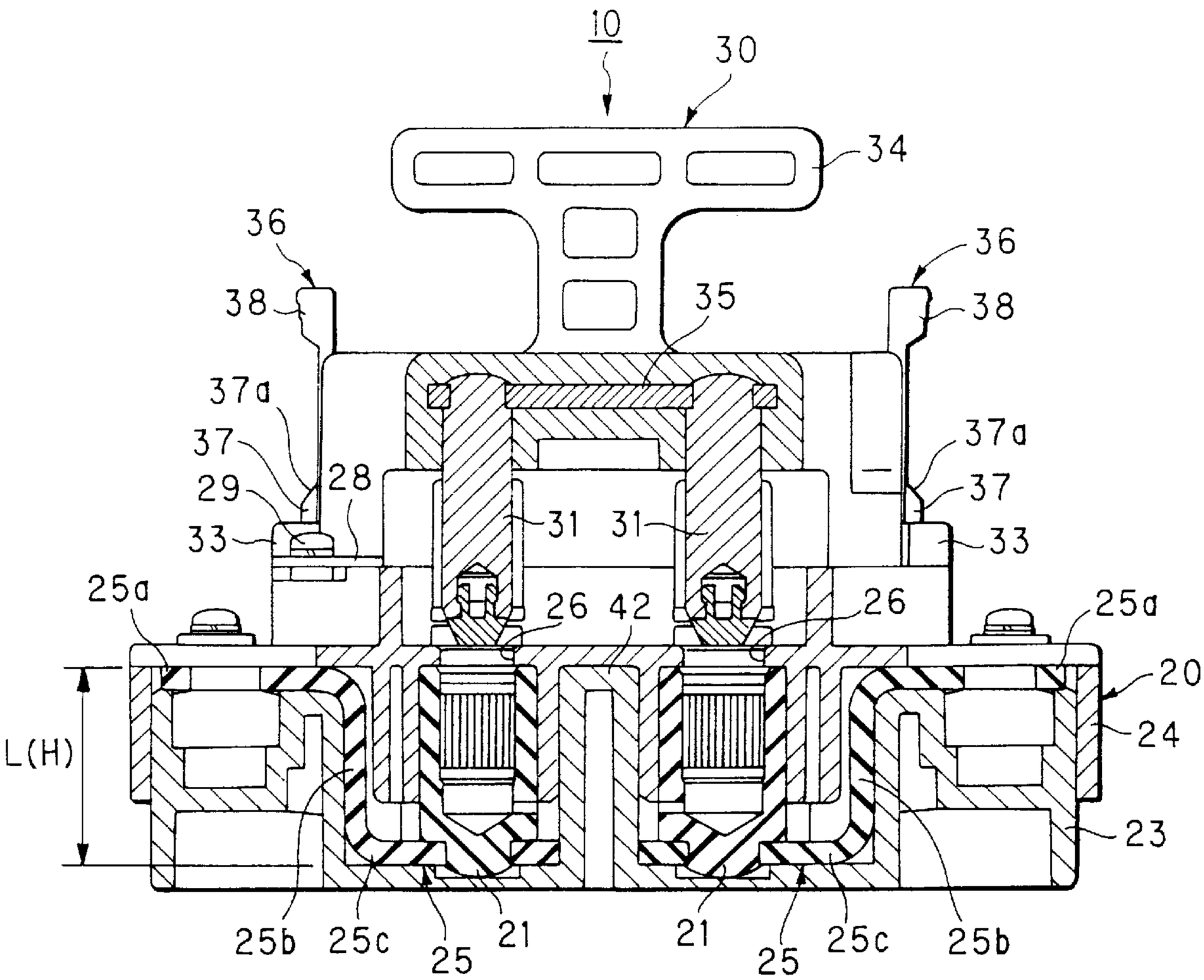
Primary Examiner—Michael Friedhofer

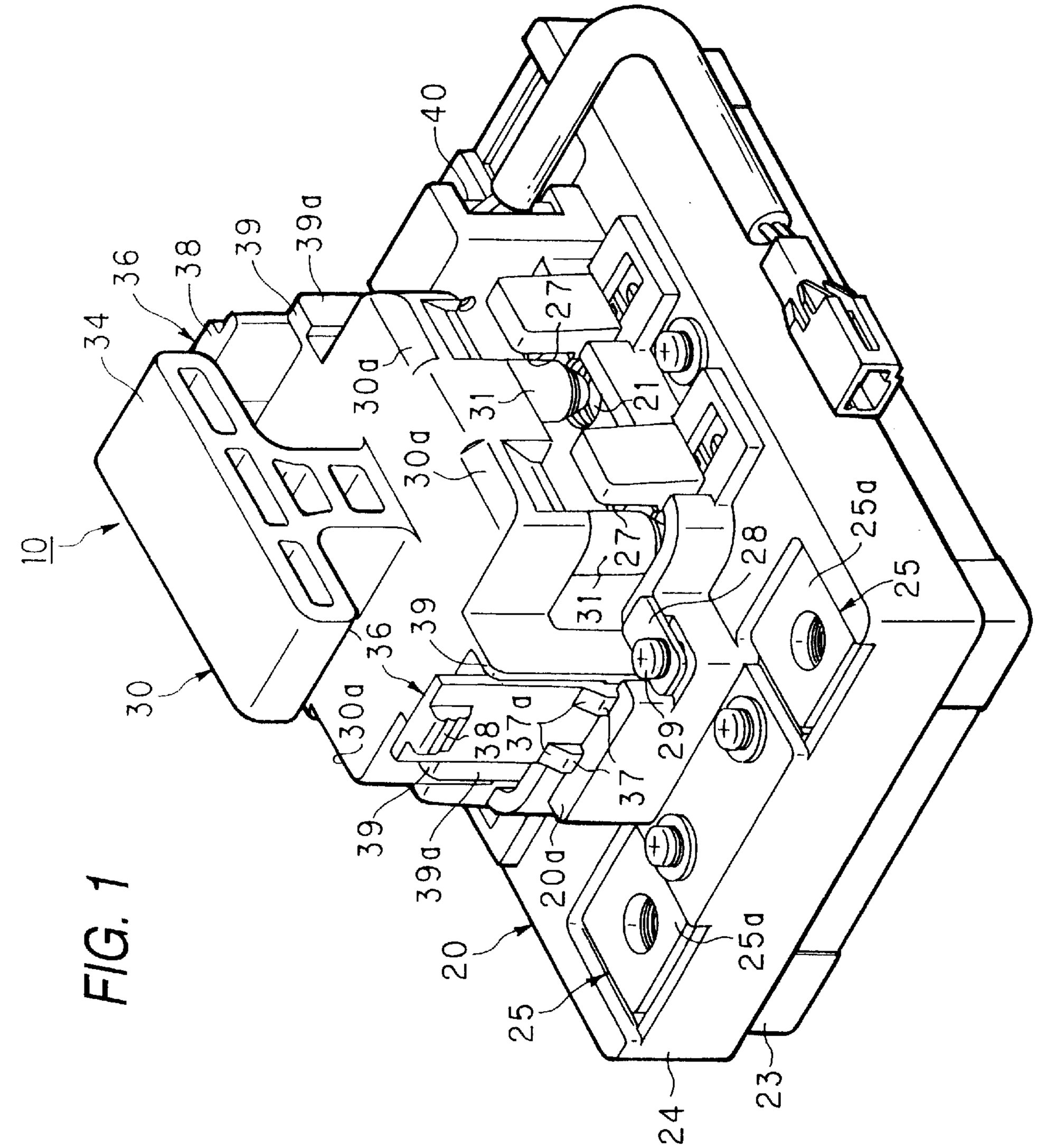
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

[57] **ABSTRACT**

An insulating rib (**42**) is provided between surfaces (**41***a*) of adjacent bus bar-receiving portions (**41**) of a box body (**23**) with which circuit terminal connection portions (**25***c*) of adjacent bus bars (**25**) are held in contact, respectively. Each insulating rib (**42**) has an internal space (**43**) communicating with the exterior of a box body (**23**) of a plug box (**20**).

3 Claims, 8 Drawing Sheets

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39a
20a
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25
25a
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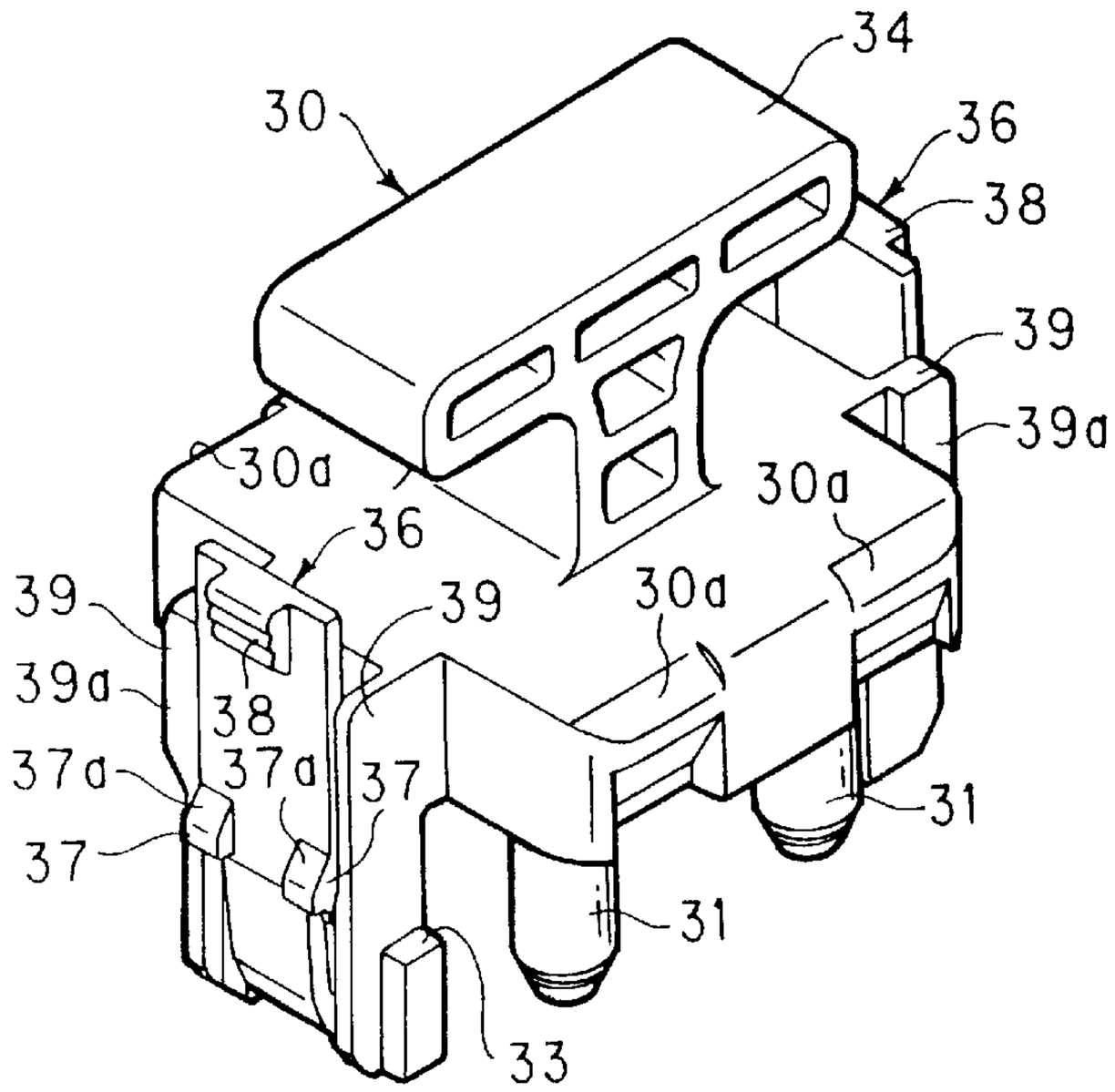
23

FIG. 1

FIG. 2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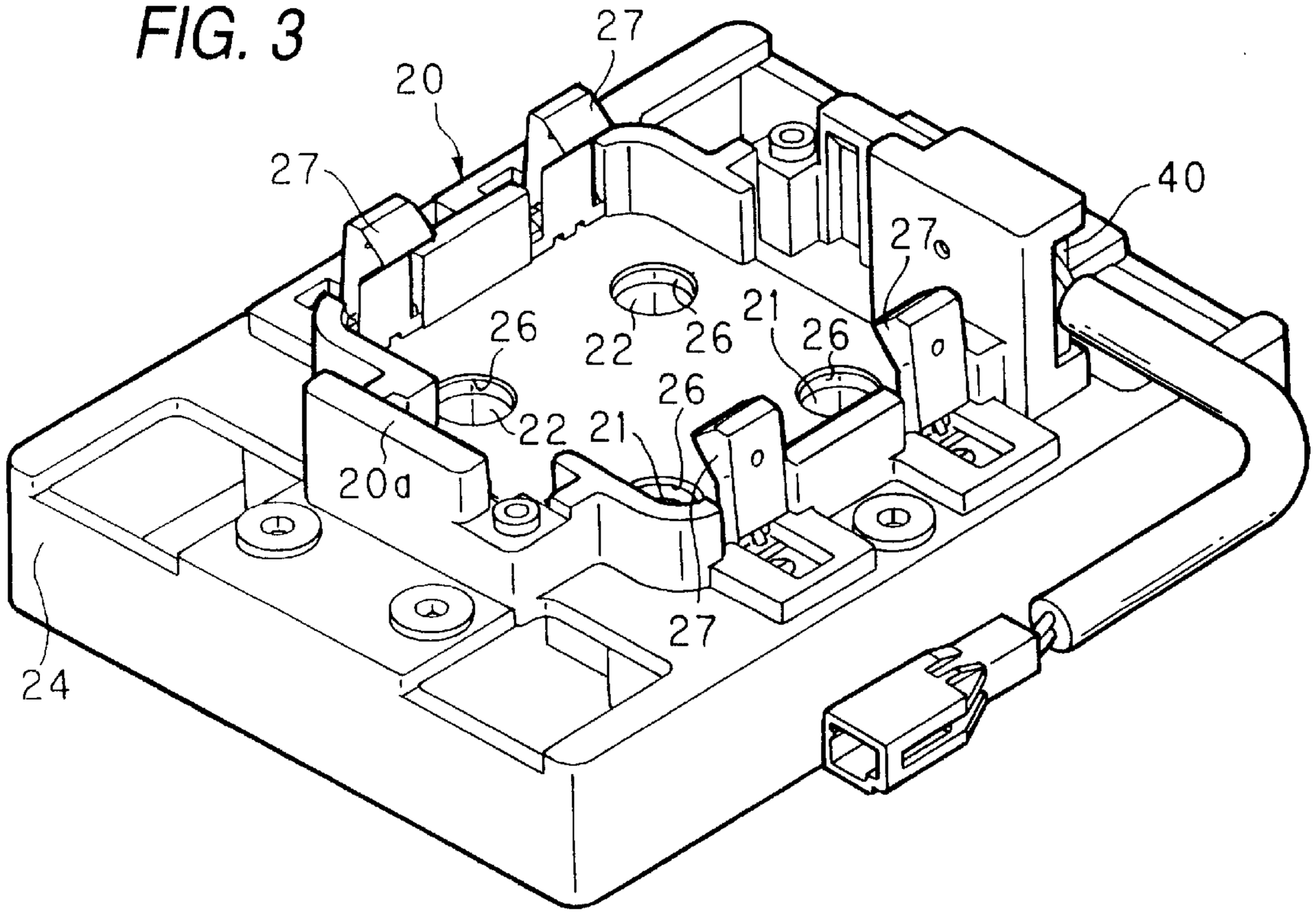
33

FIG. 3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40
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22
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26
22
21
20a
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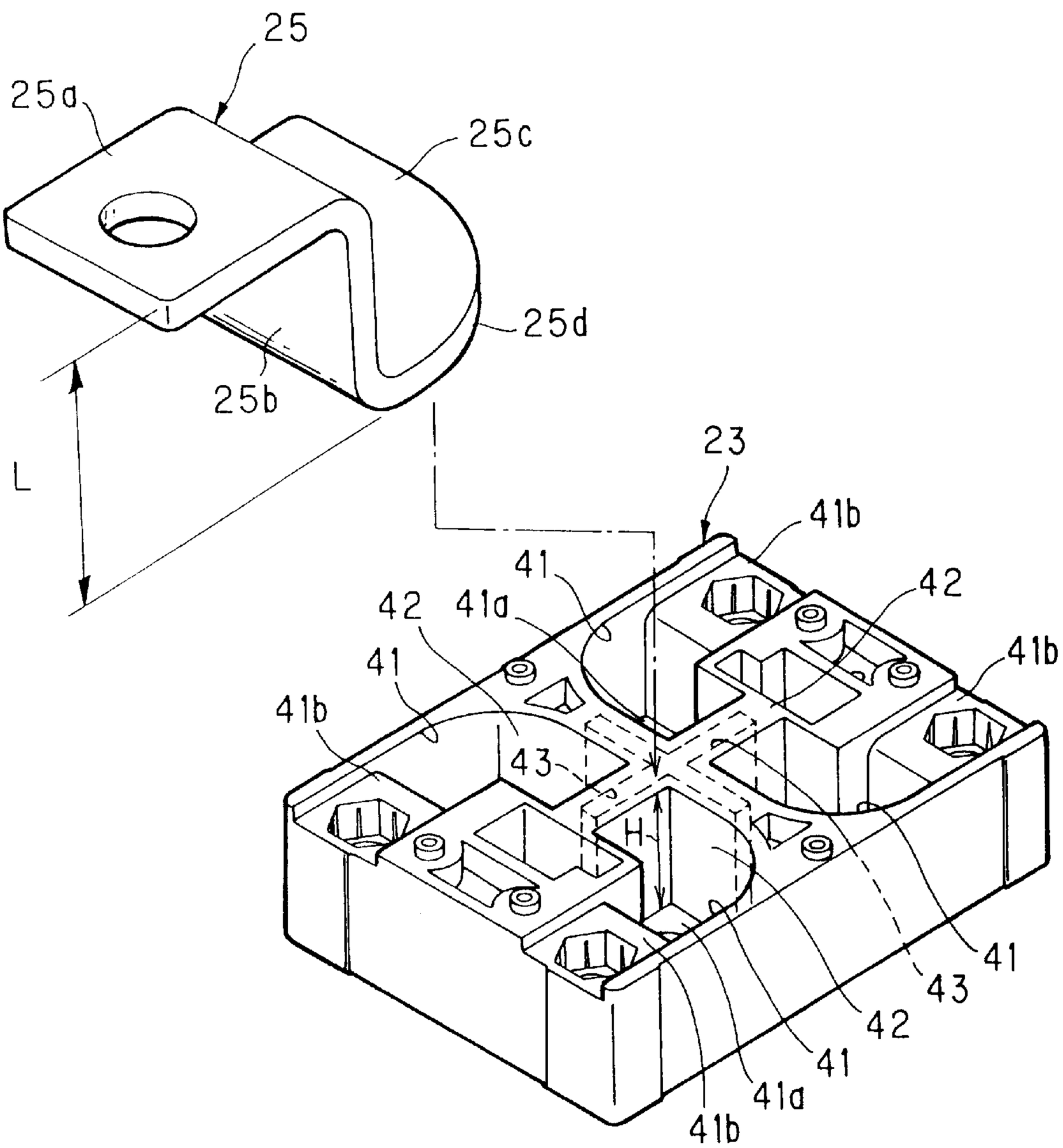
24

FIG. 4


25
25a
25c
25d
25b
L
23
41b
41
42
41a
43
H
41b
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41
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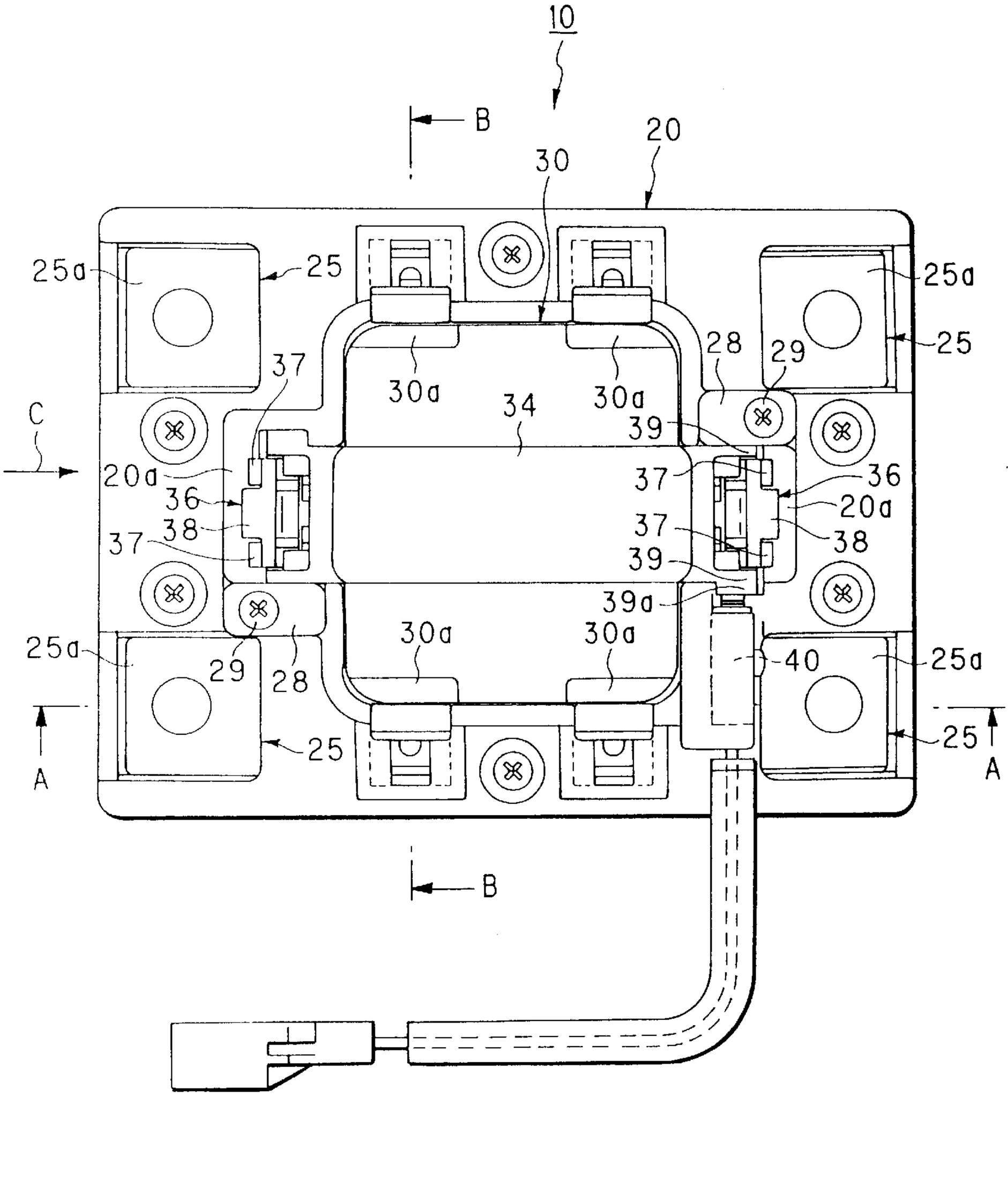
43
41
42
41
41a
41b

FIG. 5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B
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25a
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25a
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A
A
B

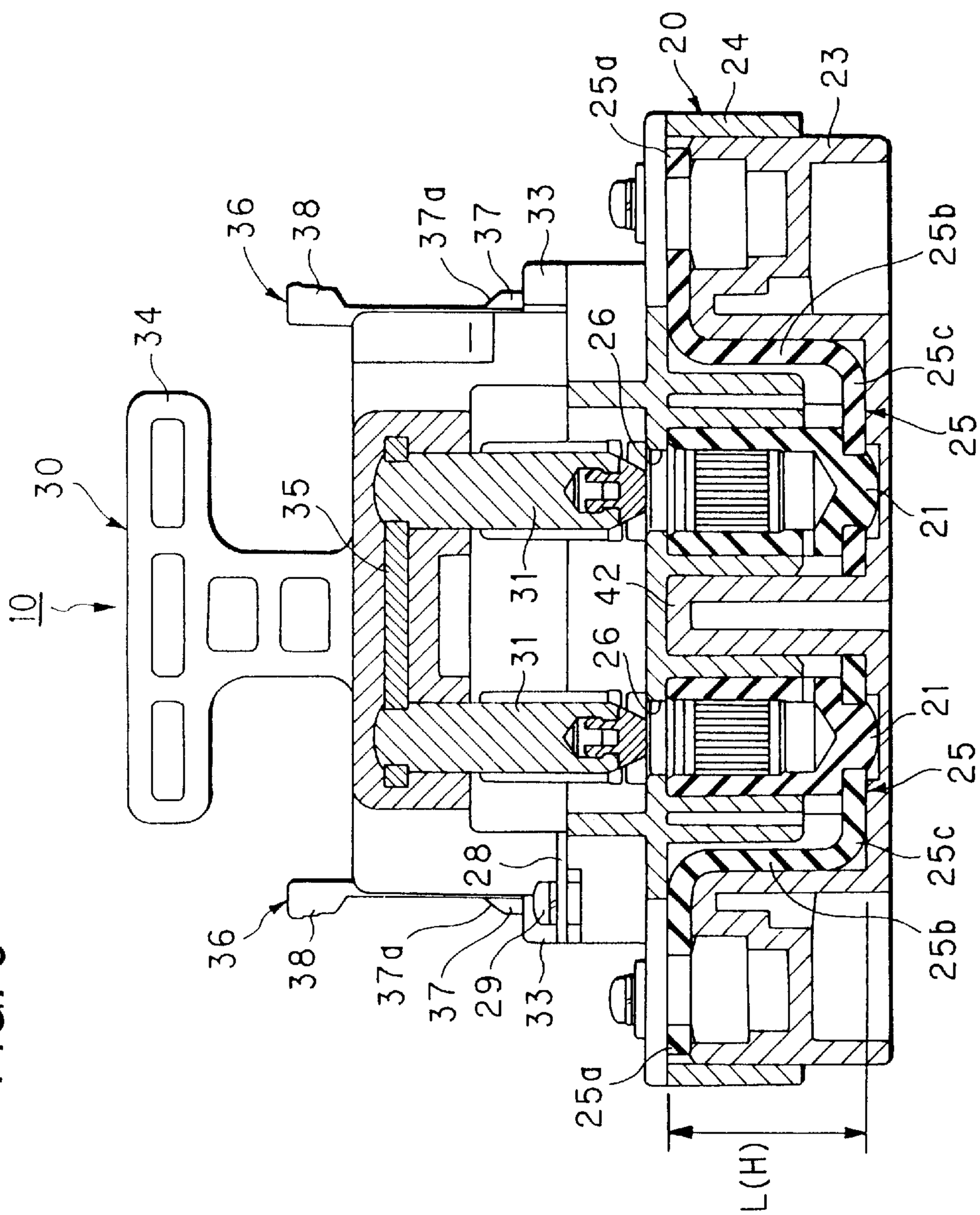
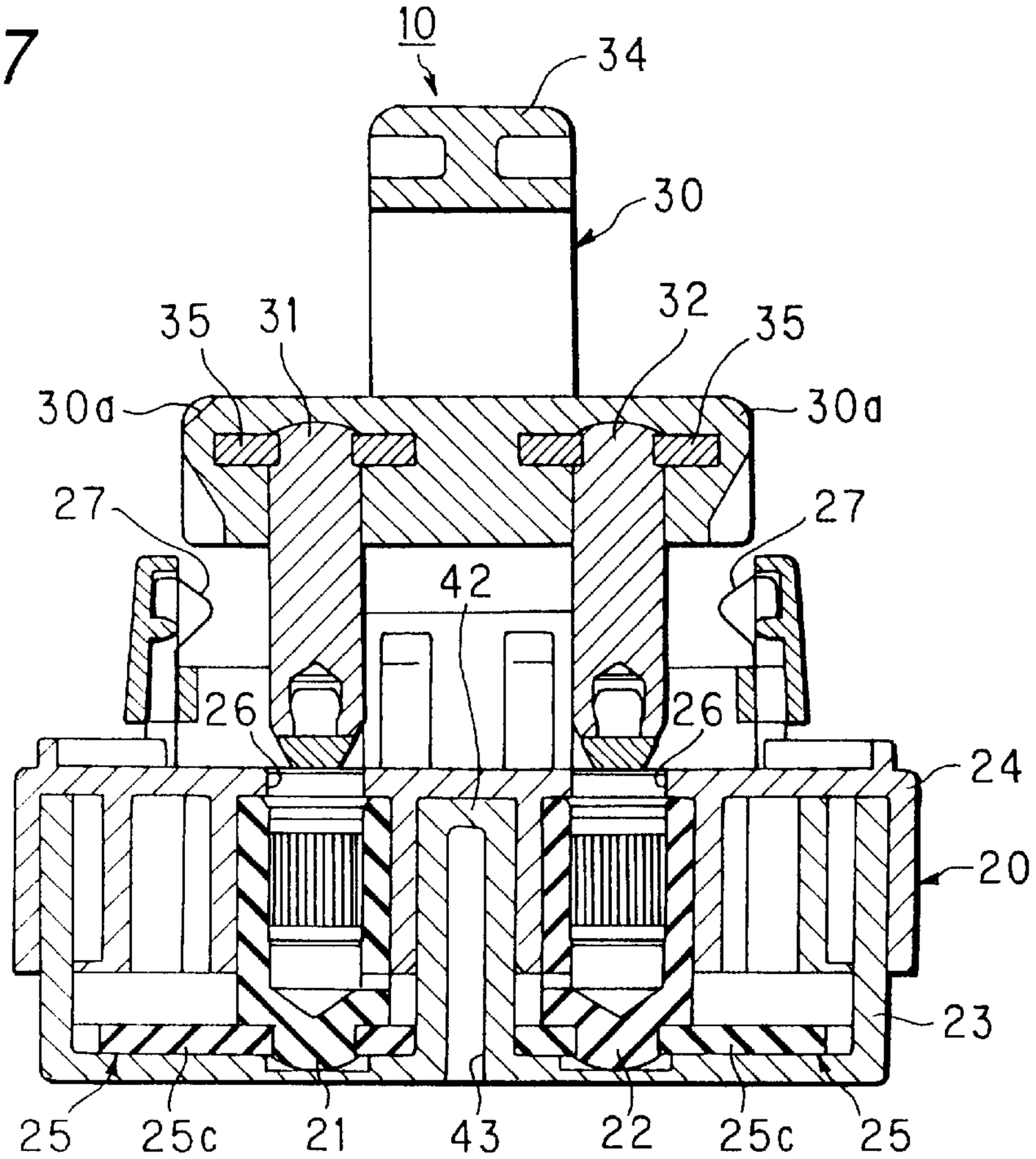


FIG. 6

FIG. 7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34
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32
35
31
35
30a
30a
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42
26
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23
25
25c
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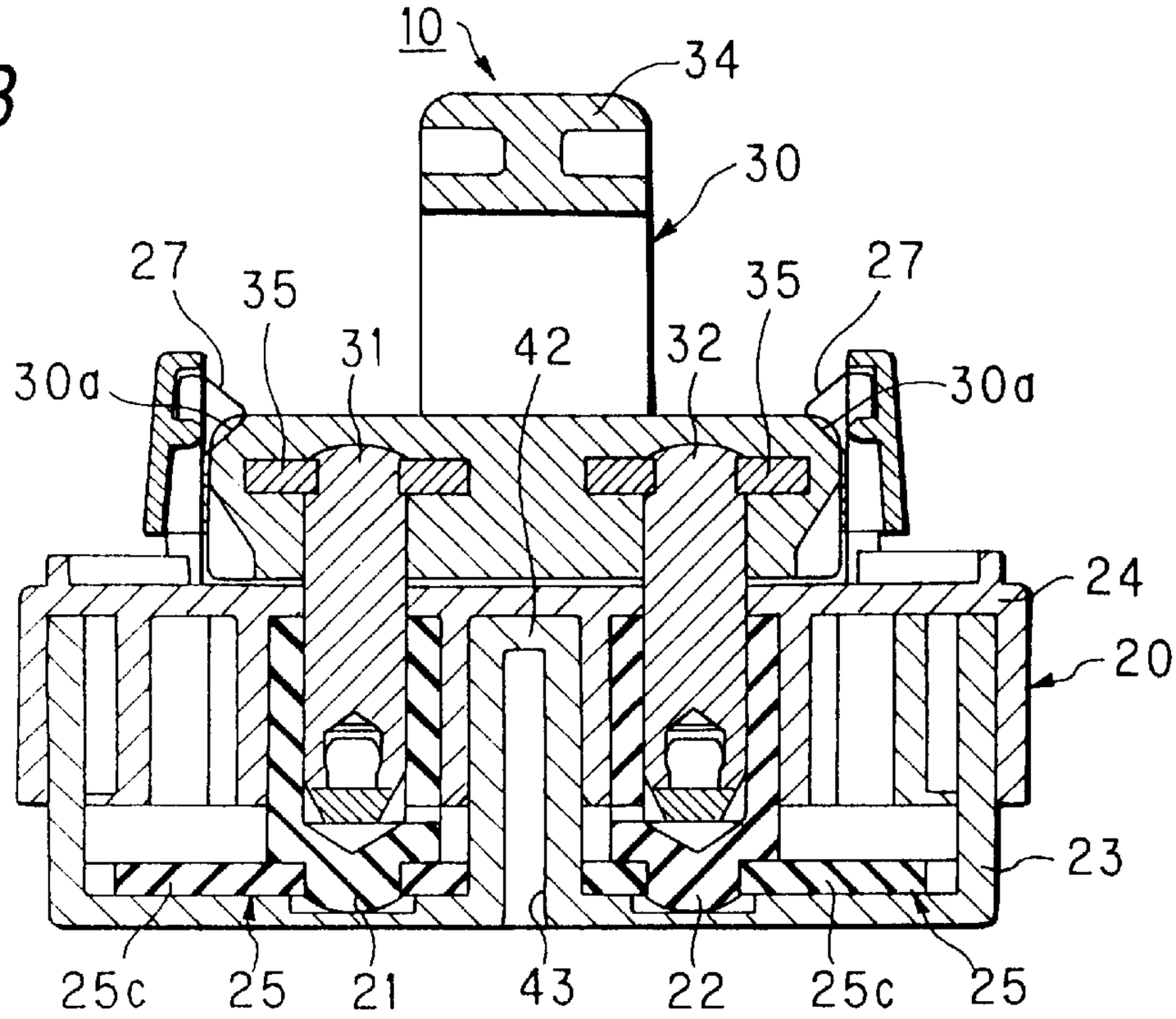
43
22
25c
25

FIG. 8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42
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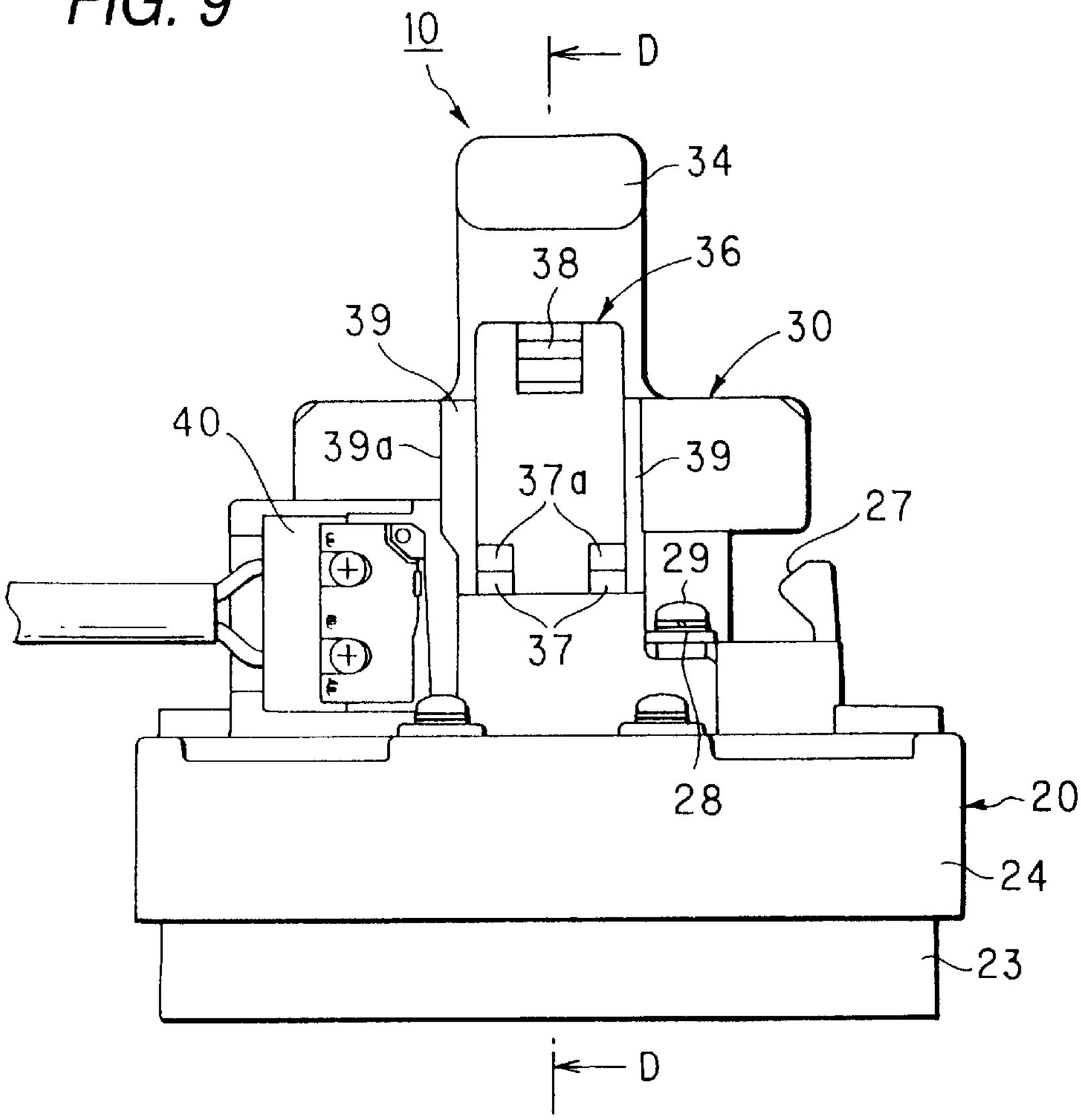
23
25c
25
21
43
22
25c
25

FIG. 9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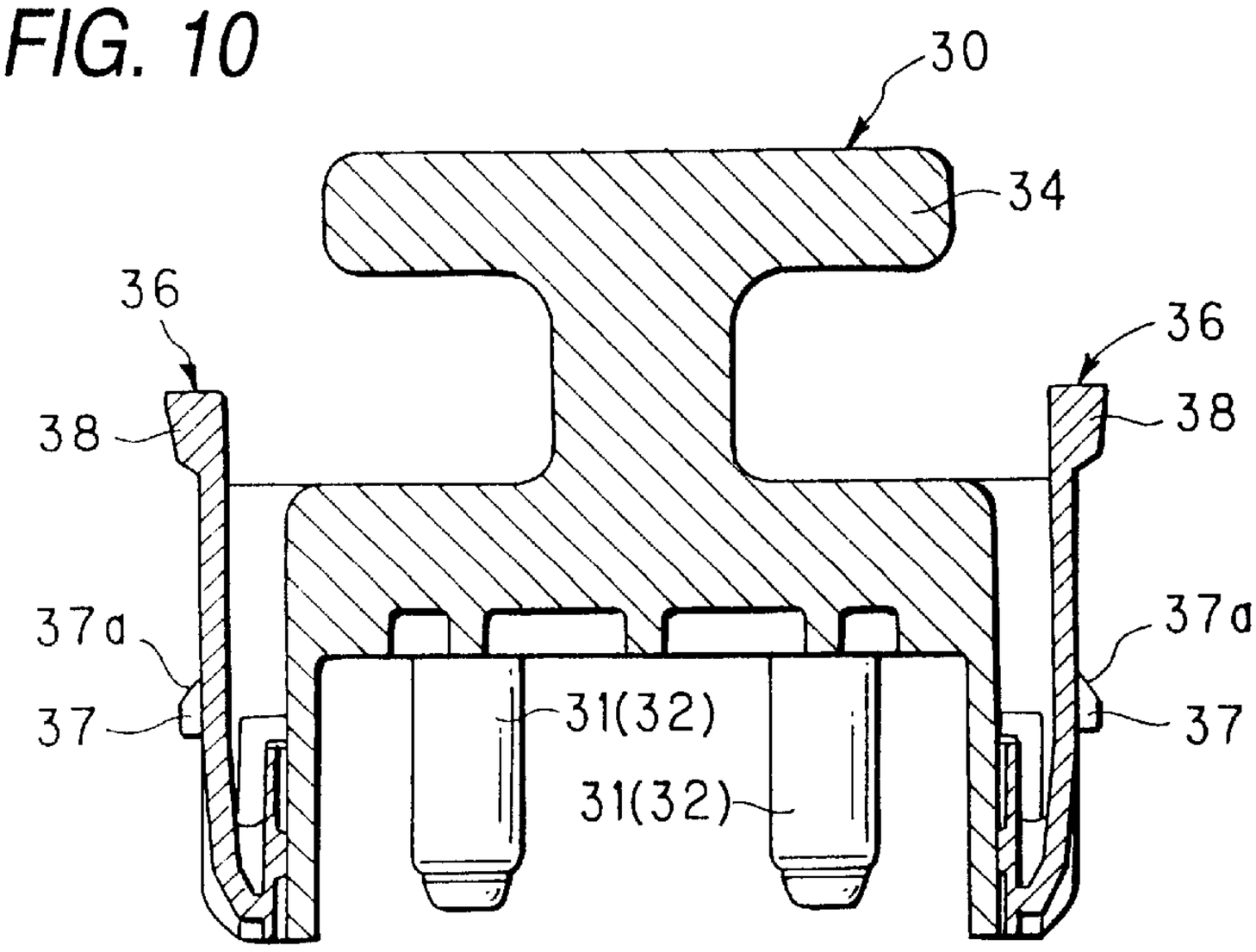
D

FIG. 10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37a
37a
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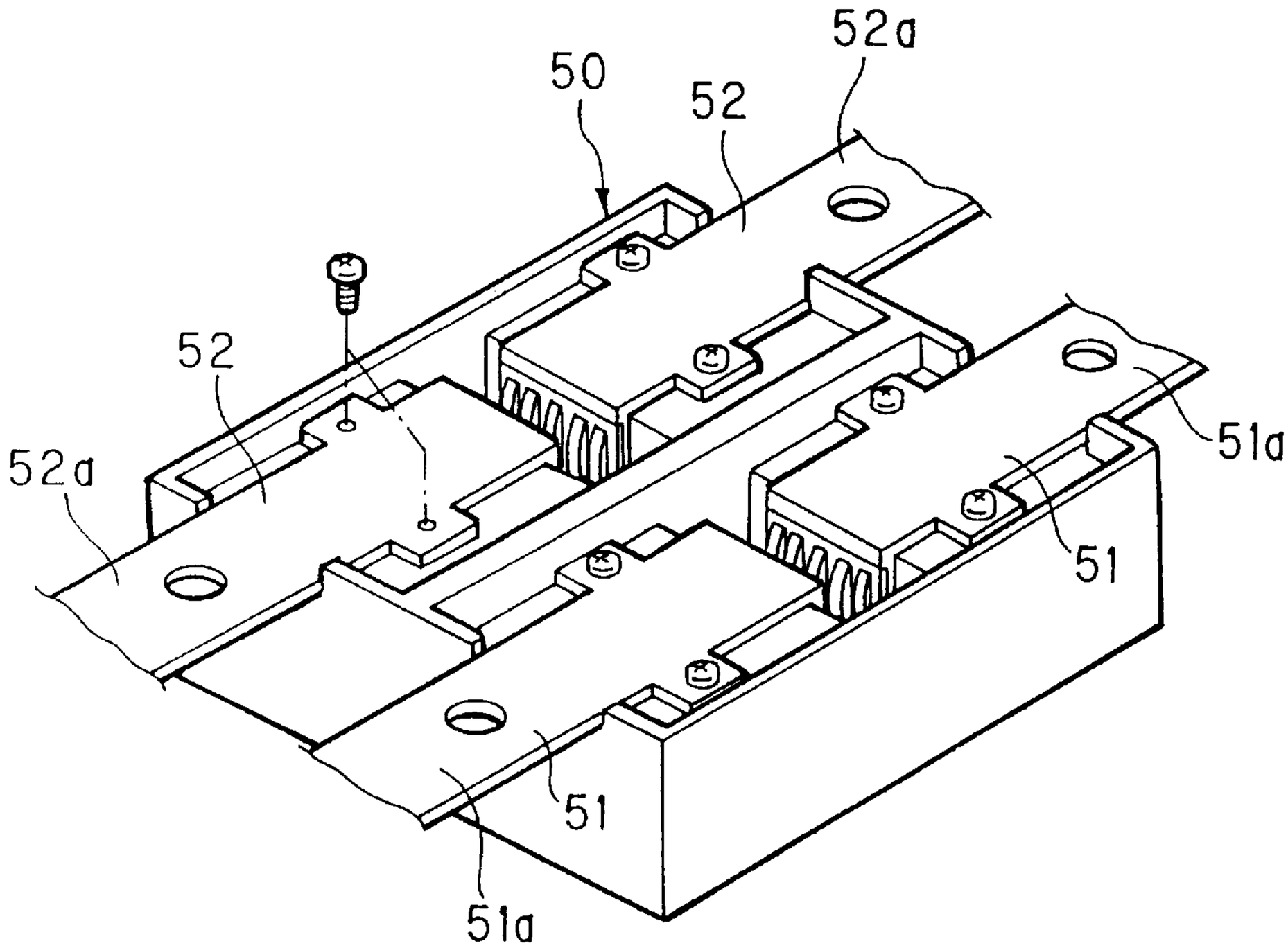
31(32)
31(32)

FIG. 11 PRIOR ART



CIRCUIT BREAKER DEVICE

BACKGROUND OF INVENTION

1. Field of Invention

This invention relates a circuit breaker device for temporarily interrupting a circuit current, for example, when performing a maintenance service (such as inspection and maintenance) of an electric car, a hybrid car or the like having a high-voltage circuit for driving a motor.

2. Related Art

A conventional circuit breaker device for an electric car or the like comprises a plug box, having circuit terminals connected to open ends of an electric circuit through respective bus bars, and a plug body having short-circuit terminals fitted in and short-circuited to the respective circuit terminals of the plug box to thereby close the electric circuit.

The plug box comprises a box body having an open top (opening), and a box cover fixed to the box body to close the opening in the box body. Referring to FIG. **11**, a plurality of (four in FIG. **11**) bus bars **51** and **52** each in the form of a flat plate are fixedly mounted on the box body **50** in such a manner that those end portions **51***a* and **52***a* of the bus bars **51** and **52** to be connected to the open ends of the electric circuit project a predetermined amount from the box body **50**.

The above conventional circuit breaker device has a problem that the pair of bus bars **51** (at the right side in FIG. **11**), arranged on a straight line, can not be sufficiently insulated from the pair of bus bars **52** (at the left side in FIG. **11**) arranged on a straight line.

Another problem is that heat is generated in the box body **50** by a circuit current in the electric circuit (high-voltage circuit) and other factor.

SUMMARY OF INVENTION

It is an object of this invention to provide a circuit breaker device in which a sufficient electrical insulation is achieved between bus bars received in respective bus bar-receiving portions of a plug box, and also a sufficient heat-radiating property is achieved.

The object of the present invention has been achieved by a circuit breaker device comprising:

- a plug box in which circuit terminals are connected to open ends of an electric circuit through respective bus bars received respectively in a plurality of bus bar-receiving portions; and
- a plug body in which short-circuit terminals are fitted in and short-circuited to the circuit terminals of the plug box, respectively, thereby closing the electric circuit, and the short-circuit terminals are disengaged from the circuit terminals, respectively, thereby opening the electric circuit to interrupt a circuit current;
- provided in that an insulating rib, having an internal space communicating with the exterior of the plug box, is provided between any two adjacent bus bar-receiving portions of the plug box.

In the circuit breaker device of the present invention, the circuit terminals of the plug box are connected to the open ends of the electric circuit through the respective bus bars received respectively in the plurality of bus bar-receiving portions.

In the plug body, the short-circuit terminals are fitted in and short-circuited to the circuit terminals of the plug box, respectively, thereby closing the electric circuit, and the short-circuit terminals are disengaged from the circuit terminals, respectively, thereby opening the electric circuit to interrupt the circuit current.

The insulating rib is provided between any two adjacent bus bar-receiving portions of the plug box, and insulates the bus bars, received respectively in the adjacent bus bar-receiving portions, from each other.

Each insulating rib has the internal space communicating with the exterior of the plug box, and heat due to the circuit current in the electric circuit and so on is radiated from the plug box to the exterior through the internal spaces.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view showing the overall construction of one preferred embodiment of the present invention;

FIG. **2** is a perspective view of a plug body of a circuit breaker device;

FIG. **3** is a perspective view of a box cover of a plug box;

FIG. **4** is a perspective view showing a box body of the plug box, as well as a bus bar;

FIG. **5** is a plan view of the circuit breaker device;

FIG. **6** is a cross-sectional view of the circuit breaker device in a provisionally-retained condition taken along the line A—A;

FIG. **7** is a cross-sectional view of the circuit breaker device in the provisionally-retained condition taken along the line B—B;

FIG. **8** is a cross-sectional view of the circuit breaker device in a completely-retained condition taken along the line B—B;

FIG. **9** is a side-elevational view of the circuit breaker device in the provisionally-retained condition as viewed in a direction of arrow C;

FIG. **10** is a cross-sectional view of the plug body of the circuit breaker device taken along the line D—D; and

FIG. **11** is a perspective view showing a plug box of a conventional circuit breaker device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** is a perspective view showing the overall construction of one preferred embodiment of a circuit breaker device of the present invention in a provisionally-retained condition. FIG. **2** is a perspective view of a plug body of the circuit breaker device of FIG. **1**, FIG. **3** is a perspective view of a box cover of a plug box of the circuit breaker device of FIG. **1**, and FIG. **4** is a perspective view showing a box body of the plug box of the circuit breaker device of FIG. **1**, as well as a bus bar. FIG. **5** is a plan view of the circuit breaker device of FIG. **1**, FIG. **6** is a cross-sectional view of the circuit breaker device in the provisionally-retained condition taken along the line A—A of FIG. **5**, FIG. **7** is a cross-sectional view of the circuit breaker device in the provisionally-retained condition taken along the line B—B of FIG. **5**, and FIG. **8** is a cross-sectional view of the circuit breaker device in a completely-retained condition taken along the line B—B of FIG. **5**. FIG. **9** is a side-elevational view of the circuit breaker device in the provisionally-retained condition as viewed in a direction of arrow C of FIG. **5**, and FIG. **10** is a cross-sectional view of the plug body of the circuit breaker device taken along the line D—D of FIG. **9**.

Referring to FIGS. **1** to **3**, in the circuit breaker device **10**, the plug box **20** has circuit terminals (female terminals) **21**

and **22** connected to open ends of an electric circuit (not shown). The plug body **30**, having short-circuit terminals (male terminals) **31** and **32** is mounted on the plug box **20** so as to be displaced between the provisionally-retained position (see FIG. **7**) and the completely-retained position (see FIG. **8**). In the completely-retained position of the plug body **30**, the short-circuit terminals **31** and **32** are fitted in and short-circuited to the respective circuit terminals **21** and **22** of the plug box **20**, thereby closing the electric circuit. In the provisionally-retained position, the short-circuit terminals **31** and **32** are disengaged from the respective circuit terminals **21** and **22**, thereby opening the electric circuit to interrupt the circuit current.

Referring to FIGS. **1** to **8**, the plug box **20** comprises the box body **23**, having a plurality of (four in this embodiment) bus bar-receiving portions **41** open to a surface thereof, and the box cover **24** fixed to the box body **23** to close the bus bar-receiving portions **41**. The circuit terminals **21** and **22** of the plug box **20** are connected to the open ends of the electric circuit through respective bus bars **25** (only one of which is shown in FIG. **4**) received respectively in the bus bar-receiving portions **41**.

The plurality of (four in this embodiment) circuit terminals **21** and **22** of a generally cylindrical shape are provided respectively at predetermined portions of the box body **23**. The circuit terminals **21** and **22** are electrically connected respectively to high-voltage wires (not shown) of the electric circuit through the respective bus bars **25**. The short-circuit terminals **31** and **32** on the plug body **30** are fitted respectively in the circuit terminals **21** and **22** through respective terminal insertion holes **26** formed in the box cover **24**.

Referring to FIGS. **4** to **6**, each of the bus bars **25** includes an electric circuit connection portion **25***a* to be connected to the open end of the electric circuit, and a circuit terminal connection portion **25***c* which is spaced a distance L from the electric circuit connection portion **25***a* in a direction of fitting of the short-circuit terminals **31** and **32** (that is, downwardly in FIG. **6**) in generally parallel relation to the connection portion **25***a*, and is connected to the connection portion **25***a* through an interconnecting portion **25***b*, and is adapted to be connected to the associated circuit terminal **21**, **22** on the plug box **20**. The interconnecting portion **25***b* extends between and are formed integrally with the electric circuit connection portion **25***a* and the circuit terminal connection portion **25***c* in generally perpendicular relation thereto, and the interconnecting portion **25***b* interconnects the two connection portions in a predetermined manner.

A corner portion **25***d* of the circuit terminal connection portion **25***c*, disposed near to the interconnecting portion **25***b*, is chamfered.

Referring to FIGS. **4**, **6** and **7**, each of the bus bar-receiving portions **41** of the box body **23** corresponds in configuration to the bus bar **25**.

More specifically, a surface **41***a* of each bus bar-receiving portion **41** for contact with the circuit terminal connection portion **25***c* of the bus bar **25** is spaced a distance, corresponding to the distance L (described above for the bus bar **25**) from a surface **41***b* thereof for contact with the electric circuit connection portion **25***a* of the bus bar **25** in the direction of fitting of the short-circuit terminals **31** and **32** (that is, downwardly in FIG. **6**).

The box body **23** has insulating ribs **42** each provided between the surfaces **41***a* of the adjacent bus bar-receiving portions **41** for contact respectively with the circuit terminal connection portions **25***c* of the bus bars **25**. Each insulating rib **42** has a predetermined dimension H in the direction of fitting of the short-circuit terminals **31** and **32** (that is, in an upward-downward direction in FIG. **6**).

The insulating rib **42** has an internal space **43** communicating with the exterior of the box body **23** of the plug box **20** (In this embodiment, the internal space **43** is open to the bottom or lower surface of the box body **23**).

The internal space **43** of the insulating rib **42** may be open to the upper surface of the box body **23**, or may be open both to the upper and lower surfaces of the box body **23**.

The electric circuit connection portion **25***a* and the circuit terminal connection portion **25***c* of each bus bar **25** are spaced a distance L from each other in the upward-downward direction (FIG. **6**), and the configuration of each bus bar-receiving portion **41** of the box body **23** corresponds to the configuration of the bus bar **25**, and the insulating rib **42** is provided between the adjacent bus bar-receiving portions **41** of the box body **23**. With this construction, the distance between the circuit terminal connection portions **25***c* of the adjacent bus bars **25** for insulating purposes is the sum of a horizontal distance (FIG. **6**) (corresponding to the thickness W of the insulating rib **42**) between the circuit terminal connection portions **25***c* of the adjacent bus bars **25** and a vertical distance (FIG. **6**) (corresponding to H×2 where H represents the dimension of the insulating rib **42**) between the adjacent terminal connection portions **25***c*.

Referring again to FIGS. **1** to **8**, two pairs of right and left (FIG. **8**) completely-retaining springs **27** are provided at the upper surface of the box cover **24**, and each pair of right and left springs **27** are disposed adjacent to right and left (FIG. **8**) ends of the box cover **24**, respectively.

The completely-retaining springs **27** are engaged respectively with spring engagement surfaces **30***a* (at upper edge portions in FIG. **8**) of the plug body **30** in the completely-retained position, and hold the plug body **30** in the completely-retained position by their resilient force.

A pair of plug body-retaining plates **28** are fixedly secured to the upper surface (FIG. **6**) of the box cover **24** by respective screws **29**, and are disposed on a diagonal line, with the center of the box cover **24** lying therebetween as viewed from the top (see FIG. **5**). The plug body-retaining plates **28** are engaged respectively with provisionally-retaining step portions **33**, formed on the plug body **30**, in the provisionally-retained position, thereby preventing the plug body **30** from being displaced beyond the provisionally-retained position in a direction away from the plug box **20**.

Referring to FIGS. **1** to **10**, the plug body **30** can be displaced relative to the plug box **20** between the provisionally-retained position (shown in FIG. **7**) where the short-circuit terminals **31** and **32** are disengaged respectively from the circuit terminals **21** and **22** and the completely-retained position (shown in FIG. **8**) where the short-circuit terminals **31** and **32** are fitted respectively in the circuit terminals **21** and **22**. The plug body **30** can be displaced between the provisionally-retained position and the completely-retained position by manually operating an operating lever **34** of a generally T-shape formed integrally with the plug body **30**.

The short-circuit terminals **31** and **32** project from the lower surface (FIG. **2**) of the plug body **30**, and are so arranged as to be opposed respectively to the circuit terminals **21** and **22**. The number of the short-circuit terminals **31** and **32** is equal to the number of the circuit terminals **21** and **22**, and is four in this embodiment. Each of the short-circuit terminals **31** and **32** has a generally cylindrical shape so as to be fitted in the associated circuit terminal **21**, **22**. Among

the short-circuit terminals **31** and **32**, the short-circuit terminals **31**, arranged right and left in FIG. **6**, are electrically connected together by a bus bar **35**.

A pair of elastic lock arms **36** are provided respectively on right and left (opposite) side surfaces (FIG. **10**) of the plug body **30**. The lock arms **36** are made of a material different from that of the plug body **30**, and are provided as separate parts. More specifically, a material, having a good heat resistance, is selected for the plug body **30** while a material, having excellent heat resistance and elasticity, is selected for the lock arms **36**.

A pair of provisionally-retaining projections **37** are formed on each lock arm **36**, and are disposed generally centrally of a length thereof. A slanting surface **37***a* is formed on an upper surface (FIG. **10**) of each provisionally-retaining projection **37**, and the thickness (dimension in the right-left direction in FIG. **10**) of the provisionally-retaining projection **37** is increasing progressively downward (FIG. **10**).

A grip portion **38** is formed at the upper end (FIG. **10**) of each lock arm **36**, and is disposed at a predetermined position relative to the operating lever **34** so that the grip portions **38** can be held respectively by the fingers of the hand operating or pressing the operating lever **34**.

When the operating lever **34** is to be manually operated or pressed so as to displace the plug body **30** from the provisionally-retained position to the completely-retained position, the grip portions **38** are gripped respectively by the fingers of the hand, operating the operating lever **34**, from the right and left sides (FIG. **10**). When the grip portions **38** are thus gripped by the fingers, the lock arms **36** are elastically deformed to be turned about their respective lower ends toward the center of the plug body.

Namely, in the provisionally-retained position of the plug body **30**, the provisionally-retaining projections **37** of each lock arm **36** are engaged with a corresponding provisionally-retaining projection engagement surface **20**a of the plug box **20**, thereby holding the plug body **30** in the provisionally-retained position.

When the plug body **30** is to be manually displaced from the provisionally-retained position to the completely-retained position, the grip portions **38** of the lock arms **36** are gripped by the fingers of the hand from the right and left sides (FIG. **10**) so as to elastically deform the lock arms **36** toward the center of the plug body **30**. As a result, the provisionally-retaining projections **37** of each lock arm **36** are disengaged from the associated provisionally-retaining projection engagement surface **20***a* of the plug box **20**, thereby allowing the displacement of the plug body **30** into the completely-retained position.

When the plug body **30** is to be manually displaced from the completely-retained position again to the provisionally-retained position, the slanting surfaces **37***a* of the provisionally-retaining projections **37** of each lock arm **36** slide relative to the plug box **20**, thereby allowing the displacement of the plug body **30** into the provisionally-retained position.

A pair of guide ribs **39** for each lock arm **36** are formed on the plug body **30**, and are disposed adjacent respectively to the opposite (right and left in FIG. **9**) side edges of the lock arm **36**, and these guide ribs **39** protect the lock arm **36** from an external force and so on. The guide ribs **39** are made of a rigid material, and project outwardly slightly beyond the outer surface of the lock arm **36**.

The left guide rib **39** (FIG. **9**) has a bulge portion **39***a* of a predetermined shape projecting left (FIG. **9**) a predetermined amount therefrom. In accordance with the displacement of the plug body **30**, the bulge portion **39** is brought into and out of contact with a microswitch **40** fixedly mounted on the plug box **20**, thereby turning on and off the microswitch **40**.

Namely, in the provisionally-retained position of the plug body **30**, the bulge portion **39***a* is held out of contact with the microswitch **40**, thereby holding the microswitch **40** in the OFF state. In the completely-retained position of the plug body **30**, the bulge portion **39***a* is held in contact with the microswitch **40** to turn on the microswitch **40**. Thus, the microswitch **40** detects the displacement of the plug body **30** into the completely-retained position (that is, the fitting of the short-circuit terminals **31** and **32** into the respective circuit terminals **21** and **22**).

The operation of this embodiment will now be described.

When performing a maintenance service, the operator pulls the operating lever **34** of the plug body **30** with the hand in a direction away from the plug box **20** (that is, upwardly in FIG. **8**), thereby displacing the plug body **30** from the completely-retained position to the provisionally-retained position with one action while flexing the completely-retaining springs **27**. As a result, the electric circuit is opened, so that the circuit current is interrupted.

At this time, the plug body-retaining plates **28** are brought into engagement with the provisionally-retaining step portions **33**, respectively, thereby preventing the plug body **30** from being displaced beyond the provisionally-retained position in a direction away from the plug box **20**. At the same time, the provisionally-retaining projections **37** of each lock arm **36** are brought into engagement with the provisionally-retaining projection engagement surface **20***a* of the plug box **20**. Therefore, the plug body **30** is positively held in the provisionally-retained position, thereby positively preventing the erroneous fitting of the short-circuit terminals **31** and **32** in the circuit terminals **21** and **22**, and so on.

For displacing the plug body **30** from the provisionally-retained position to the completely-retained position after the maintenance service is performed, the operator grips the grip portions **38** of the lock arms **36** with the fingers of the hand, operating the operating lever **34**, to elastically deform the lock arms **36**, and operates or presses the operating lever **34** of the plug body **30** (two actions). As a result, the plug body **30** is displaced into the completely-retained position while flexing the completely-retaining springs **27**, and is held in this completely-retained position by the resilient forces of the completely-retaining springs **27**.

The insulating rib **42**, provided between the adjacent bus bar-receiving portions **41** of the box body **23** of the plug box **20**, has the dimension H in the direction of fitting of the short-circuit terminals **31** and **32**, so that the vertical distance (FIG. **6**) is increased, and therefore a high insulation is secured between the circuit terminal connection portions **25***c* of the adjacent bus bars **25** without increasing the horizontal distance (FIG. **6**) between these circuit terminal connection portions **25***c*, that is, without increasing the outer size of the box body **23** of the plug box **20**.

Each insulating rib **42** has the internal space **43** communicating with the exterior of the box body **23** of the plug box **20**, and therefore heat, generated in the plug box **20** by the circuit current in the electric circuit or other factor, is radiated from the plug box **20** to the exterior through the internal spaces **43**.

In the above embodiment, the insulating rib **42**, having the internal space **43** communicating with the exterior of the box

body **23** of the plug box **20**, is provided between the surfaces **41***a* of the adjacent bus bar-receiving portions **41** of the box body **23** of the plug box **20** with which the circuit terminal connection portions **25***c* of the adjacent bus bars **25** are held in contact, respectively.

Therefore, because of the provision of the insulating ribs **42**, a high insulation can be secured between the circuit terminal connection portions **25***c* of the adjacent bus bars **25** while achieving the compact design of the box body.

And besides, heat, generated in the plug box **20** by the circuit current in the electric circuit and other factor, can be radiated from the plug box **20** to the exterior through the internal spaces **43** of the insulating ribs **42**.

As described above, in the present invention, the insulating rib, having the internal space communicating with the exterior of the plug box, is provided between any two adjacent bus bar-receiving portions of the plug box. Therefore, a sufficient insulation can be secured between the bus bars received respectively in the adjacent bus bar-receiving portions of the plug box, and also heat due to the circuit current in the electric circuit and so on can be radiated from the plug box to the exterior.

What is claimed is:

1. A circuit breaker device comprising:

a plug box in which circuit terminals are connected to open ends of an electric circuit through respective bus bars received respectively in a plurality of bus bar-receiving portions;

a plug body in which short-circuit terminals are fitted in and short-circuited to said circuit terminals of said plug box, respectively, to close said electric circuit, and said short-circuit terminals being disengaged from said circuit terminals, respectively, to open said electric circuit to interrupt a circuit current; and

an insulating rib, having an internal space communicating with the exterior of said plug box, is provided between any two adjacent bus bar-receiving portions of said plug box.

2. A circuit breaker device comprising:

a plug box having a plurality of bus bar-receiving portions and circuit terminals connected to open ends of an electric circuit through bus bars received in said plurality of bus bar-receiving portions;

a plug body in which short-circuit terminals are fitted in and short-circuited to said circuit terminals are fitted in and short-circuited to said electric circuit, and said short-circuit terminals being disengagable from said circuit terminals, to open said electric circuit to interrupt a circuit current; and

an insulating rib provided between adjacent bus bar-receiving portions to insulate bus bars received in said bus bar-receiving portions, wherein said insulating rib has an internal space communicating with the exterior of said plug box to dissipate heat generated inside said plug box.

3. The circuit breaker device according to claim **2**, wherein a shape of said bus bar-receiving portions corresponds to a shape of the bus bars received therein,

wherein the bus bars are shaped so as to have a circuit terminal connection portion which connects to the circuit terminal and an electric circuit connection portion for connecting to an open end of the electric circuit, said circuit terminal connection portion being disposed at a predetermined vertical distance from said electric circuit connection portion, and

wherein said insulating rib has a height at least the same as said predetermined vertical height, so as to insulate said bus bars from each other along the height thereof.

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